ENABLING TECHNOLOGIES

ADVANCED INDUSTRIAL MATERIALS

ENGINEERED CERAMICS/ CONTINUOUS FIBER CERAMIC COMPOSITES

INDUSTRIAL COMBUSTION

SENSORS AND CONTROLS

Supporting the development and use of innovative, energy-efficient, and environmentally friendly products and processes

U. S. DEPARTMENT OF ENERGY
OFFICE OF INDUSTRIAL TECHNOLOGIES • ENERGY EFFICIENCY AND RENEWABLE ENERGY

THE OPPORTUNITIES

Enabling technologies reduce energy use, improve environmental performance, and boost productivity and competitiveness across multiple industry sectors.

Advanced Materials

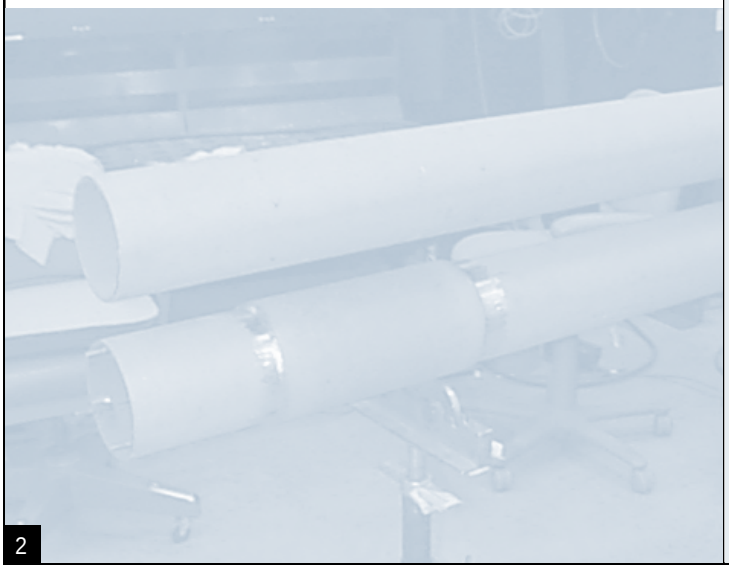
U.S. industry needs enabling materials that are stronger and lighter, with resistance to high-temperature fatigue and improved resistance to corrosion and wear. New industrial materials such as intermetallic alloys and advanced ceramics have the potential to meet the challenges of the Industries of the Future.

Combustion

The manufacturing industries obtain over 85 percent of their energy from the on-site combustion of fuels. Enhancements to burners, boilers, and process heating systems can lower energy costs, reduce emissions, enhance fuel options, and increase safety and reliability.

Sensors and Controls

Robust, integrated measurement devices linked to intelligent control systems will enable U.S. industry to use resources more efficiently and improve product quality. Through constant process monitoring and adjustment of parameters, these systems can reduce energy use and labor, minimize waste and pollution, and boost productivity.



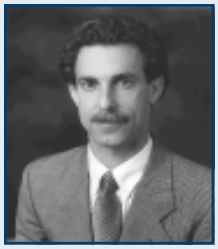
Efficiency enhancements to certain key technologies and processes used by a broad cross-section of U.S. industry will mean substantial energy and cost savings.

The Enabling Technologies Program is designed to address the cross-cutting needs of the Office of Industrial Technologies (OIT). OIT partners with industry to promote the development and use of energy-efficient, pollution-preventing technologies. The Nation's environment benefits from greater use of these technologies, and industries benefit from cost savings, improved productivity, and increased competitiveness.

As part of its Industries of the Future strategy, OIT has developed cooperative partnerships with the following energy-intensive industries:

- Agriculture
- Aluminum
- Chemicals
- Glass
- Forest Products
- Metalcasting
- Mining
- Petroleum
- Steel

Partnering for a Clean and Competitive Industry of the Future



Our nation's strength is based in large part on our access to affordable and reliable energy. As we move into the new millennium, our mission is to develop and deploy new ways to meet our energy needs and improve our environmental quality through use of renewable energy and increased energy efficiency.

Through the Industries of the Future Program, the Office of Energy Efficiency and Renewable Energy is actively engaged with U.S. industry to capture energy and natural resources savings by developing and deploying clean and energy efficient technologies and practices. Working with the nation's most energy intensive industries, we are mapping a vision of the energy future of American industry and developing the technology needed to implement that vision. This profile describes a few of the many ways that the DOE-industry alliance is working towards a more competitive future for U.S. industry and our nation.

DAN W. REICHER
ASSISTANT SECRETARY
ENERGY EFFICIENCY AND
RENEWABLE ENERGY

U.S. industry needs materials that can

- withstand high-temperature, caustic, and other harsh environments
- perform selective chemical separations
- simplify processing

Industry has identified the clear need for a variety of advanced materials as part of the Industries of the Future strategy. Industry-specific assessments of materials needs and opportunities have been provided by the end users and advanced material suppliers.

Successful development of these materials will reduce energy use, lower emissions, and increase component life. Benefits will accrue from optimization of process operating conditions and reductions in down time and waste.

The Advanced Industrial Materials (AIM) Program acts as a catalyst and facilitator, forming teams from industry, the National Laboratories, and universities to determine and assign priorities to the real materials needs of industry. Once the functional and structural materials needs have been clearly defined, the AIM Program identifies research teams capable of addressing the relevant technical and developmental issues and supports these teams in applied research, development, and applications engineering to bring the materials and processes to commercialization.

Efforts are focused on those materials and processes that will provide energy and productivity benefits to more than one of the Industries of the Future, and those that offer the greatest potential benefits in an early time frame. Every project addresses a critical need identified by industry, including research on longer-range technologies for new materials and processes. In most cases, the intellectual property rights to the material and processes belong to the DOE National Laboratories and licensing strategies have been developed to ensure widespread industrial application. Materials producers are granted exclusive licenses in narrow fields to manufacture and market materials to all segments of industry.

Case Studies

The Advanced Industrial Materials Program focuses on advanced metallic and intermetallic alloys, advanced structural polymers and membrane materials, advanced ceramics and composites, and advanced materials processing methods.

Novel Membrane

Sandia National Laboratories, working with Amoco, is developing a new membrane material, using a new generation of molecular sieves called zeolites. This material is able to separate p-xylene for production of an acid used in the manufacture of polyester. Amoco is the world's largest producer of p-xylene. Separation and purification is currently accomplished by cryogenic distillation or crystallization, which are capital- and energy-intensive processes. In addition to reducing energy consumption and capital costs, the new membranes could save approximately 400 million Btu per year if they were used by the entire U.S. chemicals industry. This technology is now being funded for demonstration by the Chemicals Industry Team.

More Efficient Chloralkali Process

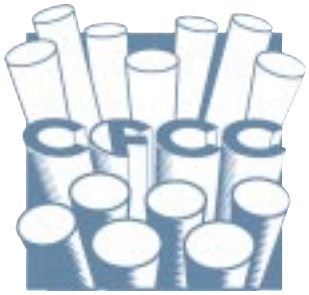
Los Alamos National Laboratory, working with Dow Chemical Company, has developed a new method for producing chlorine and caustic soda from salt solutions. Currently, this chloralkali process uses 1-2 percent of all the electrical energy generated in the United States. The new technology, derived from previous fuel cell work at Los Alamos, could save at least 30 percent of the energy required for the chloralkali process. The technology is now being funded for demonstration by the Chemicals Industry Team.

Intermetallic Alloys

Intermetallic alloys, which include a wide variety of aluminide and silicide materials, exhibit outstanding resistance to corrosion and high-temperature fatigue. The intrinsic problems of low-temperature brittleness and high-temperature creep have been solved by AIM investigators at Oak Ridge National Laboratory, and casting and welding methods have been developed for several of these alloys. As a result, Ni_3Al, NiAl, and FeAl are finding widespread applications in the Industries of the Future. Trays and fixtures for carburizing and other heat-treating applications, in which these alloys last at least ten times longer than conventional materials, are now fully commercialized. Long-lasting rolls for handling hot steel in heat-treating applications have proven very beneficial to the steel industry, and the Steel Industry Team is now funding this application and many others in the industry. Nickel aluminide dies, lasting 20 times as long as conventional materials, are now fully commercialized. Materials needs in the glass, chemicals, refining, and forest products industries have been identified, and it is likely that intermetallic alloys will solve many of the corrosion and high-temperature fatigue problems they currently encounter.

Engineered ceramics, such as Continuous Fiber Ceramic Composites (CFCCs), offer all the advantages of ceramics without the disadvantage of ceramics' brittleness. CFCCs and other engineered ceramics are recognized as a new generation of materials for use in many industrial applications.

Although many ceramics perform well at considerably higher temperatures than conventional metal alloys, they are generally brittle and, as a result, can exhibit catastrophic failure in service.



The Engineered Ceramics Program is developing and demonstrating structural ceramics (including CFFCs) technologies for industrial applications, including power generation.

CFCC material systems are being successfully developed and scaled up to sizes and shapes consistent with industry needs for key near-term and intermediate-term applications. CFCC sub- and full-scale components are being tested in application-specific environments. These applications include gas turbine components, immersion tubes for molten metals, hot gas filters, radiant burners, heat exchangers, refinery pipe hangers, and heat-treating furnace fans.

Engineered ceramics will enable advanced engines such as microturbines and reciprocating engines to have lower emissions and greater durability (greater than 18,000 hours), while meeting high-efficiency targets. Advanced microturbines/generators with advanced ceramic materials have the potential to reduce emissions to less than 9 ppm NO_x and would be able to use natural gas and a variety of liquid fuels. Target applications of ceramics include a high-speed rotor, combustor, and heat-recovery (recuperation) system.

Case Studies

Reverberatory Screens

Allied Signal has been working with Alzeta Corp. to optimize the design and installation of radiant burners with CFCC reverberatory burner screens. These screens are expected to substantially increase the efficiency of natural gas burners in industrial applications such as paper or paint drying, metal treating, and glass forming. Thermal fatigue testing, including 10,000 thermal cycles to temperatures of 2,000°F-2,200°F and 15,000 on-off cycles, has been conducted with no damage to the CFCC screens. In addition, tests of 1,000 hours at this temperature yielded no change in the properties of the screens. Radiant burners incorporating the CFCC screens have been installed in an industrial plant for field testing and evaluation.

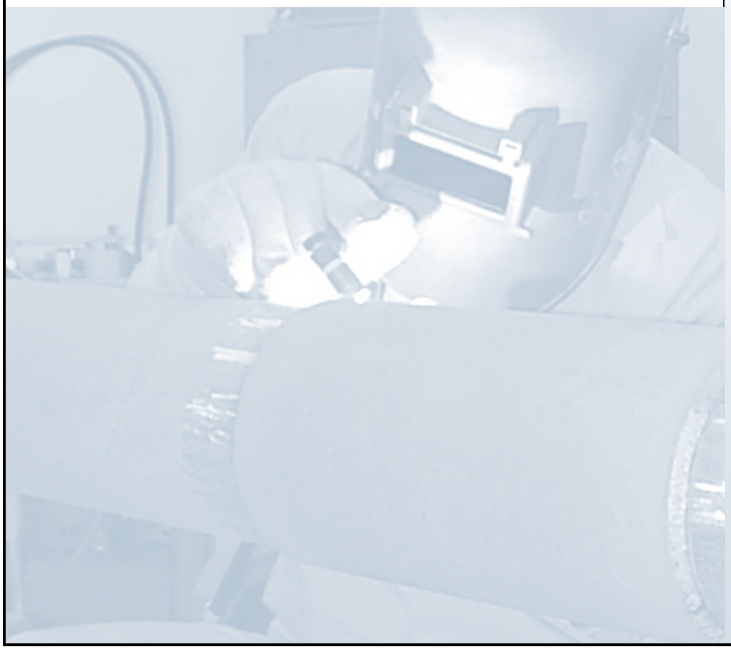
Immersion Tubes

A major automotive manufacturer is currently evaluating CFCC immersion tubes developed by Textron Systems Corporation through cost-shared funding with OIT's CFCC program. The nitride-bonded SiC-reinforced immersion tubes are being tested in an aluminum casting furnace. The goal is to replace the existing monolithic ceramic tubes in order to achieve longer life and reduce downtime. The CFCC tube in the furnace operates at approximately 1,600°F (150°F less than that needed for conventional monolithic tubes to hold the tank at the proper temperature), and has an improved overall heat-transfer efficiency of at least 40 percent. In testing performed at the automotive manufacturer's development laboratory, one immersion tube lasted more than two months, through two cold starts and 31 heating and removal cycles. A second tube is now being evaluated. It has been running successfully for more than 1,700 hours and is expected to survive for 5 months. Based upon these results, the automotive manufacturer is planning to test similar CFCC immersion tubes in another of its facilities under actual operating conditions. The goal is to eventually convert many of the manufacturer's other casting facilities to CFCC immersion tube heating.

The Industrial Combustion Program produces improvements in burners, boilers, and process heating systems.

The industry-produced combustion vision has set ambitious goals for combustion technology. The goals include energy-efficient, low-emission boilers (2 ppm NO_x is a long-term goal) that are fuel-flexible, cost-effective, reliable, and safe. Additional targets call for furnaces and process heaters that produce uniform, high-quality end products at high production rates with low specific fuel consumption and minimum environmental impact. The burners that will be used by these combustion systems are envisioned to be robust, energy-efficient, process-friendly, and reach "beyond compliance" emission levels. These burners will also use advanced flame-management systems to make them user friendly, highly reliable, and very safe. These combustion systems will be fuel-flexible, capable of burning fuels derived from industrial by-product fuels that are currently landfilled.

OIT's Combustion Program focuses on industry's priority research and development needs that also help fulfill the OIT mission of improving industrial energy efficiency and environmental performance. While increasing the efficiency of industrial combustion systems, OIT combustion activities strive to help industry meet stringent emissions targets at the lowest cost.



Case Studies

Oxy-Fuel Firing for Glass Furnaces

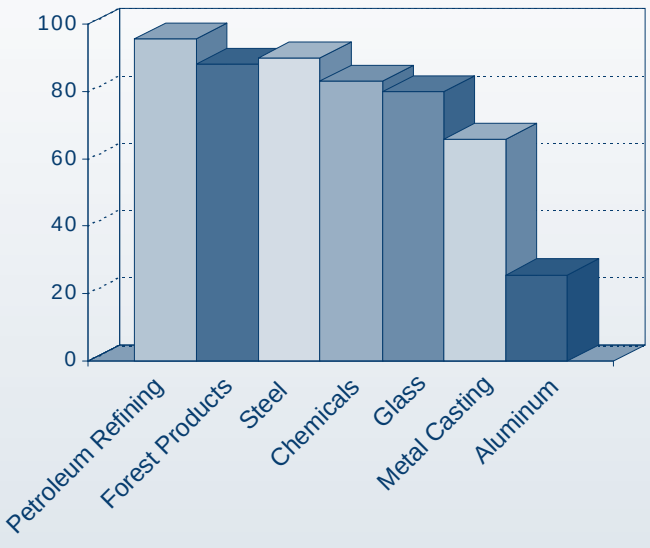
OIT, working with Praxair, Inc., and Gallo Glass, sponsored the first demonstration of oxy-fuel firing in a large glass furnace in 1991. By late 1998, over 100 glass furnaces representing one-quarter of all U.S. glass production capacity had been converted. NO_x emissions, a key driver for conversion in many areas, have been reduced by as much as 90 percent and fuel use has been cut by up to 45 percent, cumulatively saving over 13 trillion Btus.

High-Temperature Radiant Burner

Under OIT sponsorship, Alzeta Corporation has developed a high-temperature radiant burner. The burner forms the core of a thermal processor (manufactured by Edwards High Vacuum International) that destroys up to 99 percent of perfluorocarbons, a potent class of global warming gases generated during the semiconductor manufacturing process. The thermal processor has received a Best Products Award from *Semiconductor International* magazine. In less than two years since introduction, over 250 processors, each containing a high-temperature burner, have been sold worldwide.

Forced Internal Recirculation Burner

OIT has been working with the Institute of Gas Technology and Detroit Stoker Company (DSC) to produce a burner that can meet NO_x emission requirements without costly post-combustion controls. The forced internal recirculation burner has realized well below 9 ppm NO_x, and since late 1997 has logged over 5,000 hours of continuous operation heating DSC's manufacturing facilities. An extended field demonstration will take place in California this year.



% TOTAL ENERGY FROM COMBUSTION IN THE MANUFACTURING INDUSTRIES OF THE FUTURE

Intelligent control systems improve resource efficiency (energy use, labor, and capital productivity) and product quality, as well as minimize generation of waste and pollutants.

The primary goals of the Sensors and Controls (S&C) Program are to develop and deploy integrated measurement systems for operator-independent control of manufacturing processes with broad applicability across multiple industry sectors.

The S&C Program is a concerted technology development strategy to advance the science and technology components underlying the entire intelligent control systems industry, including advanced sensor technology, improved information processing, and open-architecture systems. Major benefits from this focused program include facilitating quick adaptation of technology from one process application to another and avoiding unnecessary duplication of technology development. S&C team members work with Industries of the Future teams to meet industry- and process-specific requirements.

The S&C Program will assist each of the Industries of the Future in addressing their sensor and control technology needs as identified in their technology roadmaps.

Case Studies

Intelligent Extruder

GE Corporate Research and Development, in partnership with GE Industrial Systems Solutions and Krupp Werner-Pfleiderer Corporation, has recently entered into a cooperative agreement with OIT to develop and demonstrate a novel monitoring, diagnostic, and control software system for compounding extruder lines widely used in the polymer resin manufacturing business. The technology being developed builds on inferential sensors that extract process and equipment state information from readily available, low-cost sensors and utilize that information to rapidly detect and correct process variations. Benefits of this intelligent extruder automation system include an increase in first-pass yield and a reduction in product variability, energy use, and landfill waste.

Thermal Imaging Control System

The Institute of Gas Technology has joined forces with Combustion Tec, Owens Brockway, the Gas Research Institute, and the University of Illinois to develop, demonstrate, and commercialize a near-infrared thermal imaging control system for high-temperature furnaces and combustors. The goals of the research are to develop a system that will measure temperatures in the full field of the combustion space, including walls, load, and flames, and to use that information to eliminate hot spots, improve thermal efficiency and production rate, and decrease NO_x emissions. The control system is specifically designed to work with existing furnace controllers to provide finer control than is commonly achieved. It will benefit the steel, aluminum, glass, chemicals, and metalcasting industries.

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SUPPORTING INDUSTRIES OF THE FUTURE

By facilitating the development of essential industrial technologies, the Enabling Technologies Program is helping the Industries of the Future achieve their goals.

OIT's primary strategy is the Industries of the Future, a partnership process that engages each participating industry in developing its vision of a more resource-productive, energy-efficient future, and in defining technology developments critical to realizing this vision. Based on the industry visions, OIT selectively co-funds R&D efforts. The Industries of the Future process is instrumental in focusing our Nation's top scientific and engineering capabilities, including those of National Laboratories and leading universities, on novel, high-risk technologies identified as priorities by industry.

Participating Industries are Key Targets for Energy Efficiency Improvements

Nine major industries — agriculture, aluminum, chemicals, forest products, glass, metalcasting, mining, steel, and petroleum refining — are participants in the Industries of the Future initiative. These energy-intensive industries account for about 75 percent of the energy consumed in industry.

Development of enabling technologies will allow each of these nine industries to reduce their energy consumption and costs.

HOW TO GET INVOLVED

Industry/government partnerships can bring clear competitive advantages to U.S. industry. Participants benefit from reduced cost and risk associated with collaborative research, and they also gain streamlined access to Federal scientific resources. Positioned at the forefront of technology development, these companies reap the benefits of more efficient and productive technologies and, in turn, contribute to our Nation's energy efficiency, industrial competitiveness, and environmental quality.

Ways to participate

By aligning R&D resources within industry and government to meet industry priorities, U.S. Industry will be poised to compete more effectively than ever in the global market. There are many ways to participate with the Enabling Technologies Program, including:

- Monitor our Web pages for news and announcements of R&D solicitations, meetings and conferences, and research projects (www.oit.doe.gov/).
- Team with other organizations and respond to solicitations for cost-shared research issued by Enabling Technologies, OIT's Industries of the Future, and our Financial Assistance programs. Information on upcoming solicitations can be found on the OIT home page.
- Upgrade your company's manufacturing efficiency, lower your production costs, and achieve industry recognition by participating in a demonstration of an OIT-developed technology in one of your company's facilities.
- Purchase and use in your own plants the energy-efficient products resulting from OIT technology development and demonstrations.
- Begin saving energy, reducing costs, and cutting pollution in your plant today by participating in any of the technical assistance programs.
- Call Marilyn Burgess, manager of OIT's Resource Room, at (202) 586-2090 to learn more about the listed activities and services.
- Contact the Laboratory Coordinating Council (LCC) to find out how to work with the National Laboratories and what resources are available (http://www.oit.doe.gov/LCC/).

For more information on the Enabling Technologies Program, please contact:

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